ECOSYSTEM SERVICES IN CLIMATE CHANGE ADAPTATION PROJECTS IN THE
LEAST DEVELOPED COUNTRIES OF WEST AFRICA

BY

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OCTOBER, 2018
DECLARATION

Declaration by candidate

This thesis is my original work and has not been presented for a degree in any University or any other award. No part of this thesis work should be reproduced without prior permission of the author and/ or Kenyatta University.

Signed...................................... Date......................................

Kennedy Wahome Muthee

Declaration by supervisors

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

Signed...................................... Date......................................

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Department of Environmental Sciences,

Kenyatta University

Signed...................................... Date......................................

Dr. Cheikh Mbow

World Agroforestry Center, Climate Change Unit
DEDICATION

To my wife Ann and sons Jeremy and Jermaine.
ACKNOWLEDGEMENTS

I am grateful to different organizations and individuals who contributed in one way or another in making this study a reality. I am grateful to the Almighty God for the gift of life and good health this far. May His name be praised and glorified.

I am also indebted to my academic supervisor Dr. Geoffrey Macharia and professional supervisor Dr. Cheikh Mbow for their guidance, positive critique and support throughout the study. My thanks also go to ICRAF, my host institution, for providing me with the right environment to conduct this study. I am also grateful to the staff and lecturers of Kenyatta University who contributed in one way or another to this course.

To my family, thanks for your moral and financial support and encouragement throughout the study. It may not be possible to mention all the personalities who in one way or another contributed to the success of this study but to all of you, I say thanks a lot and may God bless you abundantly for your support.
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</tr>
<tr>
<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<tr>
<td>CCSP</td>
<td>Climate Change Science Program</td>
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<tr>
<td>CRISTAL</td>
<td>Community-based Risk Screening Tool – Adaptation and Livelihoods.</td>
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<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
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<td>ICRAF</td>
<td>World Agroforestry Center</td>
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<tr>
<td>ICZM</td>
<td>Integrated Coastal Zone Management</td>
<td></td>
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<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
<td></td>
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<tr>
<td>IWRM</td>
<td>Integrated Water Resource Management</td>
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<tr>
<td>LDC</td>
<td>Least Developed Countries</td>
<td></td>
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<tr>
<td>MEA</td>
<td>Millennium Ecosystem Assessment</td>
<td></td>
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<tr>
<td>NAPA</td>
<td>National Adaptation Programme of Action</td>
<td></td>
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<tr>
<td>NDC</td>
<td>Nationally Determined Contributions</td>
<td></td>
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<tr>
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<td>UNFCCC</td>
<td>United Nations Framework Convention on Climate Change</td>
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<tr>
<td>USD</td>
<td>United States (American) Dollar</td>
<td></td>
</tr>
<tr>
<td>WCED</td>
<td>World Commission on Environment and Development</td>
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ABSTRACT

Ecosystems are largely dependent on the prevailing climatic conditions. The ever changing climate across the world has necessitated climate change adaptation projects as a coping mechanism to the adverse effects of climate change. The main objective of the study was to assess ecosystem services in climate change adaptation projects in the least developed countries of West Africa. Specifically, the study sought to; (i) assess the ecosystems changes in the Least Developed Countries of West Africa between 2000 and 2010; (ii) assess the trends in the climate change adaptation projects in the Least Developed Countries of West Africa between 2000 and 2010; (iii) evaluate the extent to which the climate change adaptation projects have incorporated ecosystem services in the Least Developed Countries of West Africa between 2000 and 2010 and (iv) evaluate areas of redesigning and improving climate change adaptation projects to enhance their ecosystem services. Different approaches were used in the study. Satellite images were used to sample the changes in the ecosystems to understand how it has changed in the entire region. Ecosystems degradation and changes have a direct impact on the climatic conditions of the region, noting that they play the essential role of capturing and storing the excessive carbon in the atmosphere. The study used desktop review approach to review 168 adaptation projects listed under the country specific National Adaptation Programs of Action in the studied least developed countries. The results showed a clear trend in the ecosystem changes. The forest covers in the three sampled countries i.e. Burkina Faso, Mali and Sierra Leone reduced by between 11% in Burkina Faso and 42% in Mali, while the Savanna increased by between 9% in Burkina Faso and 34% in Mali. The loss in forest cover translated to loss of carbon sinks and positively contributed to climate change in the region. There was also an increase in cultivated ecosystem in all countries and reduction in wetlands which all contributed towards climate change. The adaptation projects took a predicable trend whereby 32% were within agricultural sector, had generally low budget (63% had less than one million American Dollar budget) and midterm implementation duration (46% had 3 years implementation duration). About 55% of the studied projects directly mentioned one or more ecosystem services, with provisioning services being mentioned in 50% of these projects. The study also revealed that there exists opportunities to redesign the projects and improve their activities to enhance the community adaptation and mitigation to climate change effects. The adaptive measures included strengthening the ability of natural resources to play their roles while mitigation measures included creation of more carbon sinks through soil conservation and reforestation measures, investment in renewable energy sources such as wind and solar. The study concludes that the adaptation projects have considered different types of ecosystem services. It recommends increased contextualization of the climate change adaptation projects to address the community and environmental needs through more community engagement and use of technology to understand the social and environmental dynamics in a given area. The study also recommends further research on the impacts of the Great Green Wall project on the ecosystem services.
CHAPTER ONE: INTRODUCTION

1.1 Background to the study

The role played by different ecosystems in sustaining life cannot be underestimated. They, among others, maintain, strengthen and enrich different elements of life and livelihood in the planet (Prato, 2008). Further, ecosystems allow the interaction between trees, water, soils, vegetation, animals and human beings, which depend upon each other to survive on earth (Capistrano, 2005).

Ecosystems support life on the earth through provision of ecosystem services, which are defined by Wallance (2007) as the benefits that natural ecosystems provide society including clean air and water, recreating services, carbon storage, and mitigation of flood. Undoubtedly, without these services, life would be impossible on the earth for both human and non-humans. To illustrate, approximately 30 per cent of the earth is covered by forests that provide vital ecosystem services such as biodiversity habitats, food, recreational services, carbon sequestration, among others (FAO, 2006). Research by Shiklomanoy (2013) indicates that water occupies over 65 per cent of the earth’s surface with most of it being held by the oceans (about 96.5 per cent) while the rest is in the form of water vapor, rivers, lakes, glaciers, aquifer and soil moisture. According to the MEA (2005), the ecosystem services are broadly divided into supporting services, provisioning services, regulation services and cultural services. The ability of the ecosystem to deliver ecosystem services depends on its condition (healthy state) as well as the ability of the society to access it (Pramova et al., 2012).
There exists a direct relationship between the ecosystems changes and climate change. This has resulted to increased effects of climate change. According to Wallance (2007), different ecosystems such as forest, woodland and wetlands play an essential role in absorbing excessive carbon from the atmosphere and acting as carbon storage. This is achieved through both carbon cycling and carbon sequestration services that are provided by a well-functioning ecosystem. Carbon sequestration is the process through which excess carbon is captured and stored by the plants through biological, chemical and physical processes (Graven, 2017), which results to reduce carbon concentration in the atmosphere that causes climate change. Carbon cycling, on the other hand, is the process through which carbon is exchanged and recycled by the ecosystems in their natural functioning. Excessive carbon is stored by the same ecosystem that acts as carbon sink as Brouwer et al., (2011) argues.

Despite these pivotal roles played and services provided by ecosystems, the majority of them are under threat globally as a result of ecosystem degradation. Some of the major threats facing existence and services provision by the ecosystems include ecosystem conversion, climate change, loss of biodiversity, destruction and degradation of various ecosystems such as forests and wetlands (Boyd & Banzaf, 2007). According to Munang (2013), an estimated 60 per cent of global ecosystem provisional services and 70 per cent of global ecosystem regulatory services are either being unsustainably used or are completely degraded. There is a rapid increase in ecosystems degradation in the last 50 years that is not comparable to any other period in the human history as Brouwer et al. (2011) argues. Some of the factors leading to this degradation include high demand for timber, fuel, water, food among other services derived from ecosystems. According to CCSP (2018) the poor and least developed nations in the world have
the highest rates of ecosystems degradation as a result of increased reliance on them for societal existence.

To address this challenge, communities globally have put in place different measures and projects aimed at reversing ecosystem degradation. One of the common practices globally is through initiating climate change adaptation projects which directly or indirectly enhance ecosystem services. These projects are either specific to a given ecosystem (such as forest, woodland or water) or may cut across different thematic areas with the aim to improve and integrate human, biological and physical dimensions of the ecosystem (Brussard et al., 1998). In addition, climate change adaptation projects may take different scope such as local, sub national, national or regional, as well as different timelines for implementation.

1.2 Statement of the problem

West Africa, like other developing regions in the world, is still grappling with the negative effects of climate change. The region is ranked by the UN as the world’s least developed region with 13 out of 16 Countries listed in the UN list of least developed countries (UNCTAD, 2014). Some of the common indicators of climate change include temperature increase, changing rainfall patterns and high recurrence of drought. Majority of West African are continuously experiencing increased ecosystem pressure especially from anthropogenic stress, thus, affecting their functions and increasing climate change vulnerability as IPCC (2017) reports. Consequently the report estimates that the global temperatures will rise by 3-4°C by 2080-2099 as compared to 1980-1999 periods leading to an increase in the number of wet and cold years and increased aridity and semi-aridity across the region. Countries such as Mali and Burkina Faso that were
studied in this research are also facing the same predicament. As a result of unsustainable utilization of the ecosystems, their ability to provide their provision, regulation, supporting and cultural services to humans and nonhumans has been largely affected. This has necessitated an increase in adaptation based projects to curb the trend. However, linking climate change adaptation projects to ecosystems services remains a challenge and largely understudied in most climate change adaptation projects.

As such, this study sought to increase the knowledge on the ecosystem services in climate change adaptation projects in Least Developed Countries in West Africa, and propose ways of redress and improvement of the existing projects to enhance ecosystem services.

1.3 Objective of the study

The general objective of the study was to assess ecosystem services in climate change adaptation projects in the Least Developed Countries of West Africa between 2000 and 2010

1.3.1 Specific objectives

To achieve the above objective the following specific objectives were addressed:

1. To analyze the ecosystems changes in the Least Developed Countries of West Africa between 2000 and 2010

2. To assess the major trends in the climate change adaptation projects in the Least Developed Countries of West Africa between 2000 and 2010

3. To evaluate the extent to which the climate change adaptation projects have incorporated ecosystem services in the Least Developed Countries of West Africa between 2000 and 2010
4. To evaluate areas of redesigning and improving climate change adaptation projects to enhance their ecosystem services

1.4 Research questions

In view of the above problem statement the study made an attempt to answer the following questions:

1. How have ecosystems changed in the Least Developed Countries of West Africa between 2000 and 2010?
2. What are the major trends in the climate change adaptation projects in the Least Developed Countries of West Africa between 2000 and 2010?
3. To which extent have the climate change adaptation projects have incorporated ecosystem services in the Least Developed Countries of West Africa between 2000 and 2010?
4. What are the areas of redesigning and improving climate change adaptation projects to enhance their ecosystem services?

1.5 Assumption of the study

The study was limited to the projects under the country specific National Adaptation Programs of Action (NAPA). NAPA process sought to facilitate the least developed countries across the globe to establish their areas of priority based on the urgency to adapt to climate change effects and avoid adverse effects and vulnerability in future. It assumed that the NAPA documents reflects the actual state on the ground in terms of the areas of priority, and developed recommendations based on the review of these project documents.
1.6 Scope and Significance of the study

The study focused on 168 projects drawn from the NAPAs of 13 countries that are listed as least developed in West Africa. It analyzed the projects deeply and suggested ways to redesign and improve them to enhance ecosystem services. Based on the analysis, the study proposed different ways of improving these projects to meet the ecosystem service needs. The results would be of much use to individuals and organizations designing climate change adaptation projects as a guideline on how ecosystem services can be incorporated and enhanced in their projects.

1.7 Conceptual framework

The conceptual model of this study established the link between climate change and ecosystem services in the least developed countries of West Africa. The changing climate has affected the characteristics and distribution of ecosystems, in addition to affecting their natural ability of the ecosystems to provide different types of ecosystem services as established by Wallance (2007). This has necessitated climate change adaptation projects especially in the least developed countries that are more exposed to the adverse effects of climate change. These projects are categorized into three depending on the ecosystems management and benefits that they seek to provide. Projects without ES do not contribute towards enhancement of any of the categories of ecosystem services, or those projects which contribute towards degradation of ecosystems. Projects with indirect ES contributed towards promoting one or several ecosystem services indirectly through activities such as building the capacity of the communities or developing early warning systems so that the communities can adapt to climate change and enhance the ecosystem services. Projects with ecosystem services have a single or multiple ecosystem services as a part of their activities and expected results, such as provision of fodder, food, habitat, carbon
sequestration and recreation services. Modification of the projects through increased or redesigned activities had the potential of increased the ecosystem benefits realized from the project.

GIS and CRISTAL tools are preferred in the process of establishing ecosystem changes within given time period and establishing areas of project activities improvement to enhance ecosystem services respectively. The conceptual framework is summarized in Figure 1.1 below

![Conceptual framework](image)

Figure 1.1 Conceptual framework
1.8 Operational definition of terms

**Artificial/modified ecosystems** - These are ecosystems artificial by human activities such as industrial developments, mining activities, transportation, urban development, commercial/domestic developments etc (Government of China, 2014).

**Climate Change adaptation** - The adjustment in the natural or human system in response to the actual or anticipated climate stimuli or their effects (IPCC, 2007)

**Climate change** - Any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2014)

**Cultivated ecosystem** - These are ecosystems used for agricultural, horticultural, irrigation, gardening, and other farming purposes (Government of China, 2014).

**Ecosystems** - A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (MEA, 2005)

**Ecosystem resilience** - The ability of an ecosystem to cope with and respond to disturbances and to restore itself (Uppenbrink, 2018)

**Ecosystem services** - The direct and indirect benefits that human and non-humans derive from nature (Mayrand & Paquin, 2004).

**Forest ecosystem** - These are the ecosystems covered by vegetation cover of over 30% including the deciduous and coniferous forests, and sparse wood ecosystems with 10-30% cover (Government of China, 2014).

**Savannah ecosystem** - These are ecosystems with scarce shrubs and trees and more grass cover of over 30% (Government of China, 2014).

**Sustainable development** - Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).
Wetlands - These are ecosystems covered with natural and artificial water bodies such as marsh, lakes, rivers, ponds, swamps, dams, among others (Government of China, 2014).
2.1 Ecosystems changes and climate change

According to Agarwal et al. (2002), ecosystems use is the purpose for which human beings exploits the ecosystem covers such as natural vegetation, soils and biomass layer, crops and human structures covering the ecosystem surface. It looks at how human beings use ecosystems and their resources for their existence through agriculture, farming, grazing, urban development, among others. Changes in the ecosystem cover, on the other hand, refer to replacement of one ecosystem cover for another, for example, from wood ecosystem to agricultural ecosystem or from forests to wood ecosystem (Alo & Pontius, 2008). There are several determinant of ecosystem use within a given space and time. Such includes the prevailing climate, biophysical composition of the given space, and topography, as well as human factors including changes in population and technological and economic dynamics (Brink & Eva, 2009). According to Geist et al. (2006) and Riebsame et al. (2014), ecosystem use changes affect the ecosystem cover, and at the same time ecosystem cover affects the ecosystem use changes.

Changes in ecosystem covers are driven by several factors. According to Riebsame et al. (2014) ecosystem cover driven changes can be classified into two broad categories – covers driven by modification and covers driven by conversion. Covers driven by modification refer to those that are manipulated by human (anthropogenic) factors to alter the composition of the cover. For example, change from an unmanaged forest to a forest managed through controlled harvesting of timber and timber products is likely to yield an increase in forest cover. On the other hand, conversion refers to change from one type of cover to another, for example from deforestation to crop ecosystems to increase food production.
The modification and conversion in ecosystem cover affects the climatic conditions at the local, national and global scales over time. Climate remains the major determinant of the ecosystems distribution and variations in terms of the biodiversity that it holds. Changing climate has resulted to shifting in ecosystem and services that they offer to support livelihood as Grimm et al. (2017) notes. To illustrate, the changing climate has led to the shift of the desert ecosystem from north of Africa downwards towards West, East and Central Africa as Adnele et al. (2017) argues. This shift has also affected the flora and fauna biodiversity in these regions forcing some to adapt to the harsh climate condition, shift their habitat or gradually extinct. The functioning of ecosystems has also changed over time as a result of climate change. Ecosystems have changed both in terms of their properties and species distribution in the wake of changing climate. Notably, different plants and animal species have behaved differently in the wake of changing climate – with some experiencing gains and others declines. Despite many scenarios showing decrease in biodiversity in terms of growth and productivity, there are selected cases that have showed biodiversity decrease as the climate changes over time.

2.2 Global trends in ecosystem services

Ecosystem services are defined differently by different schools of thought. According to Constanza (2017), ecosystem services are benefits that both humans and nonhumans acquire through transforming ecosystem resources such as ecosystem, water and vegetation into essential goods and services that can sustain life. Some of these services include clean air and water that is obtained from forest and watersheds.
Ecosystem services are also viewed as the benefits that people obtain from ecosystems. These benefits are divided into four major categories; supporting, provisioning, regulating and cultural as Wallance (2007) argues. Provisioning services refer to the products obtained from the ecosystem such as food, fodder, energy, water and raw materials. Supporting services refer to those services that help in the production of other ecosystem services. They also support provisional, regulatory and cultural roles provided by the ecosystems such as soil formation and nutrient recycling that supports animal and plant growth. Regulating services are obtained through regulation of ecosystem processes such as carbon sequestration, air quality control, carbon storage/sinks, floods regulation and pest/diseases control. Cultural services are the nonmaterial benefits that people obtain from the ecosystems, including recreation, spiritual nourishment, education, and aesthetics roles played by the ecosystems.

MEA (2005) is inarguably the most comprehensive report on trends on ecosystem and ecosystem services. It establishes that there is a significant negative change in ecosystems as a result of human growing demand for ecosystem services such as food, timber and water. These changes have contributed to economic growth and improved wellbeing, though at the cost of ecosystem wellbeing. The report estimates that over 60 per cent of the ecosystem services are either being degraded or used unsustainably. The need for increased sustainability in the utilization of ecosystem and natural resources to aid the future generations also meet their needs.

The drivers to the changes in ecosystem and ecosystem services are varied. They can be divided into direct drivers and indirect drivers as noted by Fahey et al. (2017). Some of the direct drivers that lead to direct impact of ecosystem services include population change which has resulted
into increased ecosystem conversion for infrastructural development, agriculture, urban development, et cetera. Other direct drivers includes introduction of alien species, pollution and climate change effects that have also contributed towards shrinking the ecosystem sizes and services that they provide. The indirect drivers include the social political factors such as prevailing politics, cultural and religious factors and changes in science and technology as argued by Sonwa et al. (2018). Economic activity changes have also contributed indirectly to the changes in ecosystems and ecosystem services.

2.3 Ecosystem degradation
Degradation is a common phenomenon globally. It refers to the deterioration of the ecosystems as a result of depletion of resources such as forests, air and water (Bergström, 2011). Manmade incidents such as population growth, deforestation, over grazing, expansion of farming land and construction of cities, among others, are the major contributors to ecosystem degradation, especially in the Sahel regions. As a result, the productivity and functioning of ecosystems have decreased significantly as evidenced by loss of biodiversity, crop failure, and flash floods, among other environmental challenges associated with anthropogenic and natural factors (Boyd & Anzaf, 2007).

Between 1968-1973 and 1983-1984, West African region was faced with an extensive drought that led to the loss of trees and other forms of biodiversity as noted by Overbay (2012). The situation was accelerated by anthropogenic factors such as conversion of ecosystem and deforestation for agricultural purposes; thus threatening the functioning of ecosystems as well as their ability to cushion the community against the effects of climate change (Tschakert,
The Least Developed Countries in West Africa have initiated climate change adaptation projects and programmes with an aim to reverse the environmental degradation witnessed and at the same time help the population adapt to the permanently degraded ecosystem (IPCC, 2007).

Reports such as Republic of Sierra Leone (2014) and FAO (2011) point out that one of the most important ecosystems, the forest ecosystem, has undergone drastic decrease in the last twenty years. Forest cover has changed from 70 per cent a century ago to about 5 per cent currently due to ecosystem use changes. A study by FAO (2011) revealed that there was an extensive loss of forest cover in West Africa between 1990 and 2000, with countries such as Burkina Faso, Mali and Sierra Leone losing 0.2, 0.7 and 2.9 per cent of their forest cover respectively annually. Table 2.1 below summarizes the changes in the forest cover in West Africa between 1990 and 2000, both in terms of percentage and ecosystem mass changes.
Table 2.1: Changes in forest cover in the Least Developed Countries of West Africa between 1990 and 2000

<table>
<thead>
<tr>
<th>No.</th>
<th>Country/Area</th>
<th>Ecosystem area</th>
<th>Total forest 1990 000ha</th>
<th>Total forest 2000 000ha</th>
<th>Forest cover change 1990-2000 Annual change Annual change %</th>
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<td>Benin</td>
<td>11 063</td>
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<td>2 650</td>
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<td>27 360</td>
<td>7 241</td>
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<td>1 000</td>
<td>436</td>
<td>481</td>
<td>4 1.0</td>
</tr>
<tr>
<td>5</td>
<td>Guinea</td>
<td>24 572</td>
<td>7 276</td>
<td>6 929</td>
<td>-35 -0.5</td>
</tr>
<tr>
<td>6</td>
<td>Guinea-Bissau</td>
<td>3 612</td>
<td>2 403</td>
<td>2 187</td>
<td>-22 -0.9</td>
</tr>
<tr>
<td>7</td>
<td>Liberia</td>
<td>11 137</td>
<td>4 241</td>
<td>3 481</td>
<td>-76 -2.0</td>
</tr>
<tr>
<td>8</td>
<td>Mali</td>
<td>122 019</td>
<td>14 179</td>
<td>13 186</td>
<td>-99 -0.7</td>
</tr>
<tr>
<td>9</td>
<td>Mauritania</td>
<td>102 522</td>
<td>415</td>
<td>317</td>
<td>-10 -2.7</td>
</tr>
<tr>
<td>10</td>
<td>Niger</td>
<td>126 670</td>
<td>1 945</td>
<td>1 328</td>
<td>-62 -3.7</td>
</tr>
<tr>
<td>11</td>
<td>Senegal</td>
<td>19 252</td>
<td>6 655</td>
<td>6 205</td>
<td>-45 -0.7</td>
</tr>
<tr>
<td>12</td>
<td>Sierra Leone</td>
<td>7 162</td>
<td>1 416</td>
<td>1 055</td>
<td>-36 -2.9</td>
</tr>
<tr>
<td>13</td>
<td>Togo</td>
<td>5 439</td>
<td>719</td>
<td>510</td>
<td>-21 -3.4</td>
</tr>
</tbody>
</table>

Source (FAO, 2011)

The study by FAO (2011) clearly portrays a net loss in over 85 per cent of the countries studied within the 1990-2000 time period. This can be attributed to several factors including natural phenomenon such as droughts and forest fires and human factors such as urbanization, ecosystem conversion, and unsustainable usage of resources. There are minimal net gains in the forest cover within this time period, which can be attributed to initiatives such as reforestation and forest conservation.

2.4 Ecosystem services and climate change

Climate change has a negative effect on ecosystem and provision of ecosystem services. According to IPCC (2014) anthropogenic factors have in the last 50 years caused more destruction that is incomparable to any other periods in history, which has resulted into global
warming and climate change. In the study by Munang (2013), it is noted that over 60 percent of global ecosystems are either degraded or undergoing unsustainable usage. Further, the research indicates that over 20 percent of world coral reefs were lost, 20 percent were degraded, and 35 percent of mangrove was lost while the rate of water extraction from natural sources has doubled in the last 50 years (Munang, 2013). As a result of these activities, there is a significant increase in carbon dioxide concentration in the atmosphere that directly contributes towards global warming and climate change (Lomborg, 2016).

Research by Michelle (2012) indicates that climate change has stressed most ecosystems globally more than any comparable time in the human history. As a result, most of the ecosystems are either degraded or depleted, which in return strain them in providing ecosystem services they ought to provide in a natural setting. This has resulted into ecosystem imbalances such as shift of species from traditional habitats to new habitats, depletion and extinction of species due to climate variability and loss of biodiversity, since the available ecosystem services cannot hold and support huge biodiversity and species within their currently degraded condition (Costanza 2017; Dillaha, 2008). Scientists predict a likely tropic mismatch, alteration of ecosystem structures and functionality as well as alternation in distribution of ecosystem services (Michelle, 2012). To illustrate, climate change affects the distribution and patterns of rainfall in a given region. Poor precipitation directly affects the ability of the terrestrial, forestry and other ecosystems to meet their provisioning and supporting services to the biodiversity that depends on them. On the other hand, excessive precipitation can lead to flash floods that affect the nutrients cycles and causes washing away of top fertile layer of soil in a given ecosystem thus affecting the ecosystem’s provisioning and supporting roles (Ekppenyong, 2009). It further strains the
ability of the ecosystems to play their cultural roles such as aesthetic and religious since they are unable to support plant growth and development. Climate change also directly contributes to permanent transformation of an ecosystem to a different and degraded form when ecosystem services are unable to hold it at its initial form and condition (Wang, 2010; Heubes et al. 2011).

Provision and supply of ecosystem services is largely determined by climate conditions and human activities in a given ecosystem. These two elements determine the type, quality and functionality of the ecosystem (Heubes et al. 2011). To illustrate, the forest ecosystem vary with the forest type, trees and vegetation quality and quantity, as well as density of trees. Some areas have dense covers and others sparse cover depending on the natural and human factors surrounding the forest.

### 2.5 Climate change adaptation projects

Climate change adaptation is defined by the IPCC (2007) as the process of adjusting in natural or human systems as a response to actual or expected climate changes and their effects. Adaptation initiatives also include actions taken to moderate harm and maximize on the benefits associated with adaptation to climate change impacts and effects. Adaptation projects are classified into various categories and subgroups. McGray et al., (2007) report on Options for Framing Adaptation and Development groups the projects based on their objectives and models. The authors establish three broad categories of adaptation projects; serendipitous adaptation (projects that are undertaken for development purposes but incidentally meet adaptation objectives), climate-proofing of ongoing development efforts (whereby adaptation component is added to the project as a means to achieve the development end) and discrete adaptation (whereby projects are
purely designed to meet the adaptation objectives). The second category of the adaptation projects is based on the drivers to adaptation. The authors establish four main categories; that is projects that sought to address the drivers of vulnerability, projects aimed at building response capacity, projects targeted at managing climate risk and project that sought to confront climate change (McGray et al., 2007). Climate change adaptation projects in West Africa take different shapes, scopes and thematic areas such as energy, agricultural services; water services capacity building and forestry services.

2.6 Research gaps

Despite the existence of numerous studies in the line of ecosystem services and climate change adaptation projects, there still exist several gaps connecting the two. The MEA (2005) study addressed ecosystem, ecosystem services, and adaptation as well diverse initiatives to address issues surrounding human wellbeing. This multi-disciplinary study report is based on the on the assessment that was conducted between 2001 and 2005 to assess the contribution of various ecosystem services to human wellbeing, as well as impacts of ecosystems change to human wellbeing. It also positions human being as the main players in the ecosystems health or lack thereof, through anthropogenic factors that are influenced by social, cultural, economic and ecosystem dynamics. However, the research does not establish a clear link on how these projects enhance ecosystem services, as well as the place of ecosystem services in various climate change adaptation projects.

Munang (2013) provides detailed information about the link between ecosystem degradation and ecosystem services management and climate change, as well as the challenges hindering
effective establishment of an ecosystem services management plan. This study is to a large extent biased on the policy angle on the climate change and its effects without sufficiently establishing the position and role of ecosystem services within the adaptation projects.

A report by McGray et al. (2007) is also pivotal in framing the adaptation and development projects. The report categorizes adaptation projects according to their regions, spanning from Asia, America, Africa and small is ecosystems and developing states, as well as thematic areas such as water, agriculture and capacity building-based projects. Pramova et al. (2012) in their paper titled Ecosystem services in the National Adaptation Programmes of Action developed four different classes of adaptation projects (projects without ecosystem services, project with ecosystem services for the environment, projects with ecosystem services for social wellbeing and projects with ecosystem services for social adaptation). The study established the criteria for evaluation, their results and how projects portraying such characteristics were classified.

Despite the extensive research, there still remain several research gaps that this study sought to address. Notably, there is minimal research on ecosystem and ecosystem service changes in West Africa despite the notable ecosystem use ecosystem cover changes. Further, there is minimal research on the effectiveness of the use the CRISTAL tool in the project planning and management. The criteria used when designing the project also remains largely unstandardized.
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 The study area

This study conducted a review of the adaptation projects being implemented in West Africa as outlined in the country’s NAPA. These plans were prepared by the least developed countries across the globe under the auspices of United Nations Framework Convention on Climate Change (UNFCCC, 2011). The NAPAs describe the country specific urgent and immediate needs to adapt to climate change effects, especially in the West African region where the effects of climate change are evident. The NAPA approach was used to create a standard criterion for analyzing climate change adaptation across West Africa.

West Africa, like other global countries, is experiencing changes in climatic, social-economics, demographic and development levels, which are singly and jointly affecting the ecosystem use and ecosystem cover (Ray et al., 2017). The 21st century has recorded dramatic changes that are expected to accelerate changes in ecosystem use and cover; thus affecting greatly the people and their environment over space and time. This project sought to understand these changes that have necessitated adaptation projects as a way to cushion the communities against climate change effects as a result of ecosystem use and cover changes.

West African region is located between 4°N and 28°N, 15°E and 16°W. It has four major climatic zones. The arid zone characterizes the Sahel and Sahelian climate. The region is characterized by extended dry seasons that span to over 10 months and around 750 mm of rain during a single short rainy season as Barry et al. (2017). Countries such as Mali, Niger and parts of Senegal fall within this climatic zone. Grass ecosystem vegetation dominates this region,
while pastoralist and small-scale farming activities dominate the region. The second climatic zone is semi-arid that includes the Saheo-Sudan. Countries such as upper Guinea-Bissau, Togo, Guinea and Benin fall within this climatic zone. The area experiences between 750-1250mm of rain in average annually with prolonged dry periods as noted by Barry et al. (2017). Grass ecosystem, shrubs and acacia trees are common vegetation, which support pastoralists and small scale farms. The Sub humid zone covers upper Guinea, southern Mali, Benin, Northern Ghana, Ivory Coast and Sierra Leone. The region receives between 1250-1500 mm of rain per season according to Roudier et al. (2015). This climate condition supports grass and shrubs vegetation, as well as wide array of agricultural activities. The river valleys and wetland ecosystems within Sub humid zone also supports forests. The last climatic zone is the humid zone which has two distinct sub climatic zones, notably the Guinean (savannah zone) that has an annual rainfall of between 1500 mm and 1800 mm, and it cuts across states such as Southeast Guinea, North Liberia, parts of Ivory Coast, and Middle Ghana (Roudier et al., 2015). In the forest zone, the annual rainfall is between 1500 mm and 2000 mm with two wet and dry seasons alternating each other. Further, Barry et al. (2017) argue out that the area is largely characterized by dense tropical forests, which also supports wide range of agricultural activities. Plate 1 shows the study area in relation to the rest of Africa.
The study countries included Burkina Faso, Benin, Cape Verde, Gambia, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Senegal, Sierra Leone and Togo, which are listed as least developed by the UN. The non-study countries that did not fall under this criterion are Ivory Coast, Ghana and Nigeria.

3.2 Research design

The study took both spatial and descriptive approach. It used spatial data to analyze how ecosystem use and ecosystem cover had changed over a span of twenty years, thus necessitating
the climate change adaptation projects. A cross sectional survey was conducted in which all NAPAs were studied to assess the trends that they took and place of ecosystem services at their conceptualization stage.

3.3 Sample size and sampling procedure

Thirteen NAPAs with a total of 168 individual projects were studied after which a summary was created as a database for further analysis and presentation of results (See Annex 1 below) These are the least developed countries as ranked by the United Nations. The 168 projects were drawn from the country specific NAPA as summarized in Annex 1.

The sampling criteria were conducted as follows:

Stage 1: Development of database

This step involved compiling the list of all climate change adaptation projects falling in the country specific NAPA.

Step 2: Projects categorization

Projects were put into three main categories based on how they have incorporated ecosystem services; that is projects without ecosystem services, projects with indirect ecosystem services and projects with direct ecosystem services. Project without ecosystem services are those which do not contribute towards increasing or enhancement of any of the categories of ecosystem services, or those projects which contribute towards degradation of ecosystems. Projects with indirect ES are those which contribute towards promoting ecosystem services. This is achieved through activities such as building the capacity of the communities or developing early warning systems so that the communities can adapt to climate change and enhance the ecosystem
services. Projects with ecosystem services are those that explicitly mention single or multiple ecosystem services as a part of their activities and expected results, such as provision of fodder, food, habitat, carbon sequestration and recreation services.

These steps are summarized in Figure 3.1 below that considers the evaluation criteria used, results and classification of the projects exhibiting various sets of characteristics.

**Evaluation criteria**

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>Results</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate change adaptation projects</td>
<td>Yes</td>
<td>Project with direct ES</td>
</tr>
<tr>
<td>Is ecosystem management practice a part of the activities?</td>
<td>Yes</td>
<td>Project with direct ES</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Project without ES</td>
</tr>
<tr>
<td>Is the ecosystem management practice touching or benefiting ecosystems?</td>
<td>Yes</td>
<td>Project with indirect ES</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Project without ES</td>
</tr>
<tr>
<td>What ecosystem services elements are being enhanced?</td>
<td>Provisioning, Regulatory, Supportive, Cultural</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Areas of redesigning, improvement using CRISTAL</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.1: Sampling criteria
Step 3: Data analysis and presentation

The data was summarized and presented in form of numbers, percentages, figures and tables. The information was presented as per thematic areas, budgetary allocation, project implementation scope, implementation duration in years, and ecosystem services elements

3. Research tools

The study used two main tools for data analysis.

3.4.1 ArcGIS

ArcGIS is a Geographic Information System (GIS) tool used for creating, analyzing and displaying geographical information and maps (Gorr & Kurland, 2017). The tool has various components which allow viewing and querying maps, creating maps and performing spatial analysis as well as data manipulation. The tool was used for creating and displaying changes in ecosystems as well as distribution of projects within the study area. The information was displayed through spatial maps.

3.4.2 Community-based Risk Screening Tool Adaptation and Livelihoods – CRiSTAL Tool

CRiSTAL is a project planning tool that aids in analyzing the livelihood and environment context of the project, climate risk, and areas of improvement to enhance adaptation (www.iisd.org). CRiSTAL aimed to systematically assess the impacts of a project on some of the local determinants of vulnerability and exposure, so that project planners and managers can design activities that foster climate adaptation. A computer screenshot of the tool is shown in Plate 2 below.
Plate 2: A screenshot of the CRiSTAL Tool

The tool has three major components:

- **Community-based** – CRiSTAL focuses on projects at the local community level.
- **Risk Screening** – CRiSTAL helps users to identify and prioritize climate risks that their projects might address.
- **Adaptation and Livelihoods** – CRiSTAL helps users to identify livelihood resources most important to climate adaptation (i.e., adaptation to climate variability and change) and uses these as a basis for designing adaptation projects.

The tool’s main goal is to strengthen the role of ecosystem management and restoration (EM&R) activities in reducing the vulnerability of communities to climate-related hazards and climate change. The purpose of this tool is to understand community vulnerability to climate change and
opportunities for redress (www.iisd.org). The tool revealed proposed areas of adjustment and new activities to enhance climate change adaptation and improve livelihood.

3.5 Data collection

The ecosystem changes data was acquired from Global Land Cover datasets that provided a 30m resolution images based on the Landsat TM and ETM+ multispectral images downloaded in 2010 from the USGS site (Landsat.usgs.gov). The data was mosaicked and reclassified to meet the description of the study area. Five ecosystem use types were identified for the study, that is, forested areas; cultivated ecosystem, savannah ecosystem, wetlands, and artificial (artificial) ecosystems were studied.

In the second and third objective, data was collected from 168 projects distributed across 13 out of 16 countries in West Africa. It was reviewed in terms of their thematic areas, budgetary considerations, scope and duration of implementation, to reveal the variations that were used in establishing the trends in the climate change adaptation projects in West Africa, and were presented using tables and figures.

In the fourth objective, Cristal Tool was used in this process to establish the areas of redesigning to improve adaptive and mitigation capacities of the projects.

3.6 Data analysis

The Landsat images were analyzed using the ArcGIS to reveal ecosystem changes in the Least Developed West Africa Countries between 2000 and 2010 to address the first objective. The data collected from the NAPAs was analyzed both quantitatively and descriptively to establish the
trends in climate change adaptation projects and consideration of ecosystem services. The project
details were run through the CRiSTAL tool and the results were summarized to establish areas of
adjustment and improvement to enhance ecosystem services in the climate change adaptation
project.
CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Ecosystem changes in West Africa between 2000 and 2010

The study sampled ecosystem changes in three least developed West Africa countries, Mali, Burkina Faso and Sierra Leone, to establish the general trend of ecosystem changes between 2000 and 2010 period.

4.1.1 Ecosystems changes in Burkina Faso between 2000 and 2010

The ecosystem changes in Burkina Faso between 2000 and 2010 are summarized in Plate 3 below.

Plate 3: Ecosystems changes in Burkina Faso between 2000 and 2010

Legend

- Forest cover
- Cultivated ecosystem
- Savanna ecosystem
- Wetlands
- Artificial ecosystems
The land cover types changes in Burkina Faso between 2000 and 2010 in terms of square kilometers and percentage change (increase or decrease) are summarized in Table 4.1 below.

Table 4.1: Ecosystem cover changes in Burkina Faso between 2000 and 2010

<table>
<thead>
<tr>
<th>Ecosystem type</th>
<th>Coverage in Sq. km</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Cover</td>
<td>41,898</td>
<td>9,816</td>
</tr>
<tr>
<td>Cultivated Ecosystem</td>
<td>35,948</td>
<td>42,309</td>
</tr>
<tr>
<td>Savanna Ecosystem</td>
<td>193,530</td>
<td>220,484</td>
</tr>
<tr>
<td>Wetlands</td>
<td>2,303</td>
<td>905</td>
</tr>
<tr>
<td>Artificial Ecosystems</td>
<td>521</td>
<td>686</td>
</tr>
</tbody>
</table>

The most obvious change in the Burkina Faso’s ecosystems distribution is expansive loss of the forest cover between 2000 and 2010 which is highly attributed to human factors such as deforestation, illegal logging, and forest conversions, among others (Barry et al., 2017). According to Jax (2016), forest cover loss directly contributed to loss of wetlands since the forests act as water catchment areas, floods and soil erosion control, as well as water supply regulator. There is also a notable impact on forest cover loss to climate change. Trees absorb excess carbon from the atmosphere through carbon sequestration and also act as carbon sinks where they store the absorbed carbon. Their loss translated to increased accumulation of carbon dioxide and other greenhouse gases in the atmosphere resulting to temperature rise and climate change with its adverse effects over time. Savanna ecosystem was the most dominant among all the other ecosystems.

The study period saw a significant increase (14%) of the savanna land. The artificial and agricultural lands also increased during the study period. This clearly demonstrated shifting ecosystems distribution and characteristics, which equally impacted on the ecosystem services.
provided by these ecosystems. To illustrate, the changes in the ecosystems composition and structure through activities such as agriculture led to shift of the habitats and biodiversity occupying particular ecosystems forcing them to migrate. Modifications from natural to artificial ecosystems through manmade developments such as building, mining and construction has also greatly affected the natural ecosystems that are more adapted to the effects of climate change. The ecosystem changes in Burkina Faso have contributed to the changing climate as more natural carbon sinks are replaced by artificial and agricultural lands (Mbow et al., 2015), which in future may contribute towards increased desertification.

4.1.2 Ecosystems changes in Sierra Leone between 2000 and 2010

The ecosystem changes in Sierra Leone between 2000 and 2010 are summarized in Plate 4 below.

Plate 4: Ecosystems changes in Sierra Leone between 2000 and 2010
The land cover types changes in Sierra Leone between 2000 and 2010 in terms of square kilometers and percentage change (increase or decrease) are summarized in Table 4.2 below.

<table>
<thead>
<tr>
<th>Ecosystem type</th>
<th>Coverage in Sq. km</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Cover</td>
<td>63,739</td>
<td>41,534</td>
</tr>
<tr>
<td></td>
<td>35% (-)</td>
<td></td>
</tr>
<tr>
<td>Cultivated Ecosystem</td>
<td>1,040</td>
<td>939</td>
</tr>
<tr>
<td></td>
<td>10% (-)</td>
<td></td>
</tr>
<tr>
<td>Savanna Ecosystem</td>
<td>4,520</td>
<td>6,751</td>
</tr>
<tr>
<td></td>
<td>50% (+)</td>
<td></td>
</tr>
<tr>
<td>Wetlands</td>
<td>2,203</td>
<td>2,230</td>
</tr>
<tr>
<td></td>
<td>1% (+)</td>
<td></td>
</tr>
<tr>
<td>Artificial Ecosystems</td>
<td>238</td>
<td>286</td>
</tr>
<tr>
<td></td>
<td>20% (+)</td>
<td></td>
</tr>
</tbody>
</table>

The most notable ecosystem change in Sierra Leone between 2000 and 2010 was loss of forest cover by 35%. It is notable that dense forest covers that were evident in the Montane forest zones of the country were slowly converted to savanna lands that are characterized by less trees and shrubs and more grass cover. Some of the worst affected areas included the Tama Tonkolili and Nimini Hills that lost over half of the tree cover paving way for savanna, artificial and cultivated ecosystems as noted in the figure above. There are several factors that have led to this change in the study area. Study by Sonwa et al., (2018) argues that population increase, slash and burn agriculture, logging, mining, shift agriculture, and human developments are among the major factors contribution to ecosystem changes in Sierra Leone especially loss of forest cover and expansion of the other ecosystems. To illustrate, shift agriculture that is common in Sierra Leone is characterized by burning, clearing and farming of the forest ecosystem for a short period after which the land is left fallow for several years natural rejuvenation. The process takes longer for the ecosystem to be restored as compared to the rate at which conversion takes place as Raudsepp-Hearne et al. (2010) leading to changes in the functioning of the ecosystem services and increased climate change effects as more carbon sinks are lost through human factors. It is
notable that wetlands recorded minimal changes during the study period. This is associated to the loss in the forest cover which plays a pivotal role of water catchment and supply of water in different watershed.

4.1.3 **Ecosystems changes in Mali between 2000 and 2010**

The ecosystem changes in Mali between 2000 and 2010 are summarized in Plate 5 below.

![Ecosystems distribution in Mali in 2000](image1.png) ![Ecosystems distribution in Mali in 2010](image2.png)

Plate 5: Ecosystems changes in Mali between 2000 and 2010

The land cover types changes in Mali between 2000 and 2010 in terms of square kilometers and percentage change (increase or decrease) are summarized in Table 4.3 below.

<table>
<thead>
<tr>
<th>Ecosystem type</th>
<th>Coverage in Sq. km</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2000</td>
<td>2010</td>
</tr>
<tr>
<td>Forest Cover</td>
<td>151,424</td>
<td>50,057</td>
</tr>
<tr>
<td>Cultivated Ecosystem</td>
<td>304,808</td>
<td>425,640</td>
</tr>
<tr>
<td>Savanna Ecosystem</td>
<td>598,908</td>
<td>828,583</td>
</tr>
<tr>
<td>Wetlands</td>
<td>81,860</td>
<td>32,140</td>
</tr>
<tr>
<td>Artificial Ecosystems</td>
<td>3,000</td>
<td>3,581</td>
</tr>
</tbody>
</table>
Mali recorded a significant increase in the savannah, artificial and cultivated ecosystems, and loss in the forest and wetlands ecosystems during the 2000 and 2010 period. The cultivated and savanna ecosystems remained the most dominant during this period with a significantly high rate of increase at 40% and 38% respectively. The increase in these ecosystems is largely attributed to the human activities in this study area during the study period, including farming, development, and mining activities (Ray et al., 2017) which are the major contributors to the ecosystem modification and changes. The expansion of the sandy areas has also transformed the once productive areas to arid and semi-arid areas which are progressively pushing southwards towards the cultivated and savannah lands as the Sahara desert expands from the North towards the south. The study by Mbow et al. (2015) establishes that the savannah and agricultural ecosystems have dominated over the once natural ecosystems, especially the forests that dominated the south western region of the country. Increasing population and the need to feed this growing population amidst negative effects of climate change such as crop failure and reduced crop productivity has led to overutilization of the land for agricultural purposes and conversion of forests to savannah and agricultural lands (Epule et al., 2013). Mechanisms such as irrigation are on the rise to address this challenge. On the other hand, it has negative effect towards the wetlands that also decreased significantly by 61% in the study period. This is well evident in areas such as Niger River and inland Niger delta which are among the major sources of water in Mali. Natural habitat destruction is a major environmental issue in Mali. Forests decreased by 67% during the study period as a result of population and agriculture pressures that led to clearing of forests causes severe water erosion, which removes the topsoil, reducing land productivity and creating conditions that lead to desertification as summed by Fahey et al. (2017).
4.2 Trends in climate change adaptation projects in West Africa

4.2.1 Climate change adaptation projects distribution per country

A total of 168 projects were studied from the thirteen least developed countries in West Africa. From the study, Mauritania had the biggest number of the projects at 28 while Cape Verde and Liberia had the least at 3 each. The distribution of the projects per countries is summarized in Table 4.4 below.

Table 4.4: Climate change adaptation projects distribution per country

<table>
<thead>
<tr>
<th>No</th>
<th>Country</th>
<th>No. of projects</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Burkina Faso</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Benin</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Cape Verde</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Gambia</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Guinea</td>
<td>25</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Guinea Bissau</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>Liberia</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>Mali</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>Mauritania</td>
<td>28</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>Niger</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>11</td>
<td>Senegal</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>Sierra Leone</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>13</td>
<td>Togo</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>168</td>
<td>100</td>
</tr>
</tbody>
</table>

The projects varied with thematic areas, budgetary considerations, scope and duration of implementation. These variations were used in establishing the trends in the climate change adaptation projects in the Least Developed Countries of West Africa.
### 4.2.2 Sector distribution and variation

The study established that different countries had different areas of priorities based on their contextual needs. Nine categories of project thematic areas were established in the study and the results of the projects distribution per country and per thematic areas were summarized as per Table 4.5 below.

Table 4.5 Climate change adaptation projects distribution per thematic areas

<table>
<thead>
<tr>
<th>Country</th>
<th>No. of projects</th>
<th>Agriculture</th>
<th>Coastal resources</th>
<th>Early warning systems</th>
<th>Capacity building</th>
<th>Energy</th>
<th>Health</th>
<th>Water resources</th>
<th>Forestry resources</th>
<th>Cross cutting themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina Faso</td>
<td>12</td>
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<td>0</td>
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<tr>
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<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>Gambia</td>
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</tr>
<tr>
<td>Guinea Bissau</td>
<td>14</td>
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<td>1</td>
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<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mauritania</td>
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<td>9</td>
<td>4</td>
<td>0</td>
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<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Niger</td>
<td>14</td>
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<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Senegal</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>Sierra Leone</td>
<td>24</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>4</td>
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<tr>
<td>Togo</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| Total in No.   | 168             | 53          | 21                 | 7                     | 18                | 6     | 10     | 31              | 17                 | 5                    |
| Total in %     | 100             | 32          | 13                 | 4                     | 11                | 3     | 6      | 18              | 10                 | 3                    |
Studies such as Howitt & Pienaar (2016) have concurred that agricultural and water sectors are the worst affected by the effects of climate change in West African countries. Water is already a scarce commodity in this region, and its demand is likely to increase in future. Climate change has made this problem worse. Higher future temperatures will increase evaporation lowering water supply and also increase the demand for water for irrigation, cooling, and other uses (Lomborg, 2016). The agriculture sector is the largest current user of water. Agriculture is responsible for 70% of water withdrawals in West Africa (Epule et al., 2013) necessitating adaptation measures that are geared towards enhancing water efficient agricultural strategies. The interrelationship between water and agricultural sector is inarguably the major reason why the two sectors are leading in terms of the number of climate change adaptation projects. These findings are consistent with those of Pramova et al. (2012) that singled out agriculture as the main area of focus in climate change adaptation due to the historical food insecurity in Africa. West Africa is among the regions in Africa that has been hard hit by the effects of climate change, as characterized by episodes of crop failure and droughts (McGray et al., 2007). Other sectors such as coastal resources management, forestry resources, and capacity building initiatives also had considerable number of climate change adaptation projects. These varied with specific country based on the ecosystems characteristics, location and distribution of biodiversity.
4.2.2 Distribution and variation according to fund allocation

The climate change adaptation projects in West Africa are largely implemented with a small to medium budgetary allocation as revealed in Figure 4.1 above. The findings further indicated that there is a low financial consideration on the climate change projects. The funds allocation to a given sector is a clear indication of the economic, environmental and social priorities and needs within that country. With the known effects of climate change to the nation economy, it was expected that more funding will be allocated to the adaptation projects to enhance adaptation abilities of the ecosystems. From the projects analyzed, the financial allocation ranged from below 1 million USD to over 4 million USD, indicating low prioritization of the adaptation initiatives.

From the above results, it is evident that there is an insignificant financial investment for adaptation. This is in concurrence with the UNEP Adaptation Finance Gap Report (2016) that
pointed out insufficient funds allocation to adaptation measures compared to the magnitude of the challenge posed by climate change in different sectors of the economy. This ultimately exposes the communities and ecosystems to climate change effects, whose cost of adaptation may rise to between 280 and 500 Billion by 2050 (UNEP, 2016). Wamunyima and Miga (2014) further note the need for concerted efforts to innovatively increase finances for adaptation to cushion the society from the high economic costs in future as a result of climate change effects.

Considering the negative effects of climate change to different sectors of economy, the budgetary consideration is low and exposes the communities and ecosystems to these effects. Budgetary constraints are one of the major challenges facing the implementation of adaptation projects, especially in Africa. Going forward, different researches have noted the need for increased financial support from both national and international sources to support mitigation and adaptation exercises. Financial support is also critical in building capacity of the communities, project implementations for long-term and short-term adaptation exercises (Pramova et al. 2012), and creating awareness to communities on local and indigenous adaptation knowledge.

4.2.3 Distribution and variation based on the project implementation scope

The scope of the projects was established in terms of their proposed geographical and spatial coverage. Projects were classified within the local, sub-national and national distribution. Table 4.6 below summarizes the project distribution per country per geographic/spatial scope.

Table 4.6: Projects distribution per scope of implementation

<table>
<thead>
<tr>
<th>Scale</th>
<th># of projects</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>39</td>
<td>23</td>
</tr>
<tr>
<td>sub-national</td>
<td>82</td>
<td>49</td>
</tr>
<tr>
<td>National</td>
<td>47</td>
<td>28</td>
</tr>
</tbody>
</table>
Majority of the projects (49%) took a sub national scope covering several districts or provinces, as well as different eco-regions while 28% were nationally distributed and 23% were local projects. The projects scope in most cases considered the political boundary context. To illustrate, the *Aménagement et gestion de la mare d’Oursi* project (Development and management of the pond Oursi) in Burkina Faso sought to sustainably improve the lives and livelihood of the communities living around Oursi Pond, through among others, restoration of the pond’s water storage capacity, wetland watershed management and reversing degradation as outlined in Burkina Faso NAPA (2007). However, it is notable that most ecosystems are not confined to only one political boundary, hence the need to consider the whole ecosystem when designing an adaptation project.

Political boundary context was considered in most projects during the scoping stage. It is notable that the impacts of climate change are essentially local; thus the climate change adaptation measures should be locally contextualized to address the local transformations. This is achieved through understanding the local needs and challenges, and developing initiatives that solve the local needs largely using the available local resources or expertise. Nalau *et al.* (2015) note that the management of climate risk can only be realized when the adaptation initiatives are implemented at the local level to support the local communities adapt and mitigate the effects. This cumulatively yields global effects towards adaptation and mitigation. However, the study established that majority of the adaptation exercises are within the sub national and national levels creating havoc in adaptation especially in the wake of Paris Agreement and Nationally Determined Contributions (NDCs), where most of the adaptation initiatives have been localized to meet the climate change adaptation goals as noted in the study by Nalau *et al.* (2015).
4.2.4 Distribution and variation based on the duration for implementation

Climate change adaptation projects are implemented within a given duration of time, after which the projects either come to a closure or it is extended depending on the availability of resources. The project scope in this study ranged from below 1 year to over 5 years. The results are summarized in Table 4.7 below that considers the projects distribution per country per the number of years on implementation.

Table 4.7: Climate change adaptation project distribution per implementation duration

<table>
<thead>
<tr>
<th></th>
<th>Total projects</th>
<th>Duration (Years)</th>
<th>&lt;1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>&gt;5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burkina Faso</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Benin</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cape Verde</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gambia</td>
<td>10</td>
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<td>3</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Guinea</td>
<td>25</td>
<td>4</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Guinea Bissau</td>
<td>14</td>
<td>0</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Liberia</td>
<td>3</td>
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<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mali</td>
<td>19</td>
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<td>7</td>
<td>9</td>
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<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Mauritania</td>
<td>28</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td>7</td>
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</tr>
<tr>
<td>Niger</td>
<td>14</td>
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<td>11</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>4</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>24</td>
<td>0</td>
<td>1</td>
<td>16</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Togo</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Total Number</strong></td>
<td><strong>168</strong></td>
<td><strong>5</strong></td>
<td><strong>51</strong></td>
<td><strong>75</strong></td>
<td><strong>12</strong></td>
<td><strong>24</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total in %</strong></td>
<td><strong>100</strong></td>
<td><strong>3</strong></td>
<td><strong>30</strong></td>
<td><strong>45</strong></td>
<td><strong>7</strong></td>
<td><strong>14</strong></td>
<td><strong>1</strong></td>
<td></td>
</tr>
</tbody>
</table>

Climate change adaptation projects fell within short-term, mid-term, and long-term implementation periods. It is notable that most of the projects sought to be implemented within a short duration with 45% falling within 3 years implementation period. Short term
implementation of the climate change period can be attributed to several reasons such as inadequate funding to execute the projects for a longer time, as well as inadequate political goodwill from the political class to support financially the adaptation exercises. This factor can be attributed to several factors such as inadequate resources to execute the projects for a longer time and insufficient political goodwill from the political class to financially support the adaptation exercises. Boone (2008) noted that most developing countries lack the political leadership and commitment to support adaptation activities in their countries. Ultimately, this exposes the communities to the dangers of climate change effects. This finding also suggests that the planned adaptation is low compared to the scoping strategies put in place. Research by Roudier et al. (2015) explains the necessity of allowing climate change adaptation projects sufficient time to enable them go through the whole stages of the project cycle successfully and achieve the desired outcomes. This is closely tied with the project implantation budget and resources consideration, which as noted above are equally limited.

4.3 Ecosystem services incorporated in the climate change adaptation projects

4.3.1 Type of ecosystem services provided by the climate change adaptation projects

The study established and categorized ecosystem services into four major categories, being provisioning (84 projects), regulating (42 projects), supporting (27 projects) and cultural services (projects). Notably, 13 of the studied projects did not incorporate ecosystem services provisions. These results are discussed below.
4.3.1.1 Provision services

Provision services refer to the products (goods and services) that are obtained from ecosystems. This study identified six provisional services (food provision, water provision, provision of fodder/pasture/forage, provision of non-timber products (such as gum and honey), provision of forest products and provision of fencing products. 84 projects (accounting for 50% of the total number of projects studied) sought to provide diverse provisioning services as summarized in the Table 4.8 below.

Table 4.8: Provisioning services provided by the climate change adaptation projects

<table>
<thead>
<tr>
<th>Provisioning services</th>
<th>Fencing</th>
<th>Non-timber products</th>
<th>Timber products</th>
<th>Water</th>
<th>Fodder pasture Forage</th>
<th>Food</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Projects</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>19</td>
<td>20</td>
<td>36</td>
<td>84</td>
</tr>
<tr>
<td>% no. of projects</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>23</td>
<td>24</td>
<td>43</td>
<td>100</td>
</tr>
</tbody>
</table>

From these results, it is evident that most of the climate change adaptation initiatives seek to provide the community with one or more benefits from nature. There is more biasness towards putting more climate change measures in place to aid the nature to continue providing tangible benefits to the communities around it. This may, however, translate to ecosystem degradation when there is an increase in the extraction of the ecosystem services to levels that do not match the climate change adaptation initiatives put in place. The study by Sonwa et al. (2018) reveals that the increased extraction of the provisioning services provided by nature such as food and timber is among the drivers of ecosystems conversion and driver to climate change. This is evident in West Africa where countries studied have increasingly experienced changes in nature as a result of increased extraction of these resources from the ecosystems.
4.3.1.2 Support services

Projects with ecosystem support services were 27, accounting for 16% of the total projects studied. Some of the established support services include the support of biodiversity, support of soil formation/productivity/fertility, support of the development of coastal resources and support of habitats. Figure 4.2 below summarizes the number of the support services provided by different adaptation projects.

![Support services provided diagram]

Figure 4.2: Climate change adaptation projects providing support services

Supporting services play an essential role in the wellbeing of the ecosystems. They are necessary in the production and maintenance of all other ecosystem services. It is, however, noted that there were minimal consideration of climate change adaptation activities in the projects studied at 16%. This is attributed to several factors. Research by Braat & Groots (2012) established that the impacts of supporting services are indirect as opposed to all other ecosystem services that have direct impact to the communities. To illustrate, soil and biodiversity support services strengthens the ecosystems in playing their provisioning, cultural and regulatory services. This
maybe one of the contributing factors to the low consideration of support services in the climate change adaptation projects. The study by Raudsepp-Hearne et al. (2010) also reveals that the supporting services play a crucial role in maintaining the conditions for the life on earth. Soil formation support, for example, aids the soil in remaining productive and enhancing the crop yields, without which the productivity decreases over time. These services may not be directly detected especially in the short-time, but their long term impacts are evident. Extraction of ecosystems to provide energy is among the major causes of climate change. Activities associated with energy cycling reduces overreliance on ecosystems for energy, thus indirectly contribution to reduced effects of climate change. This calls for more consideration of supporting services in the climate change adaptation projects for long-term benefits of ecosystem services.

4.3.1.3 Regulating services

42 projects studied (accounting for 25%) sought to provide regulatory services as summarized in Figure 4.3 below.
Regulatory services are the regulation benefits that nature provides, including erosion, siltation, water quality, fire control, pollution, disease and floods control. Erosion control was the most dominant regulating service provided by the climate change adaptation projects studied. This is attributed to several factors, including the regular occurrence of flash floods that are attributed to the effects of climate change. A study by Jax (2016) revealed that regulatory services are most crucial in averting the effects of climate change through absorbing the excess carbon from the air and acting as carbon sinks to store the absorbed carbon. Further, they ensure that nature provides clean and healthy benefits to the human life through regulating the quantity and quality of the provided services. These essential roles are considered in the climate change adaptation projects studied. Notable, the regulatory services such as water quality and siltation control and provide...
direct benefits to the ecosystem users, a factor that contributes to high consideration of regulatory services in the climate change adaptation projects.

### 4.3.1.3 Cultural services

The study established two cultural services, that is tourism/ecotourism development and recreational services. The projects providing these services were *Coastal Defense System for the Cities of Buchanan and Monrovia: Reducing the vulnerability of coastal urban areas (Monrovia, Buchanan) to erosion, floods, siltation, and degraded landscapes project* in Liberia that sought to provide recreational and tourism services through development and rehabilitation of beaches. Secondly, *Establishment of new Forest Reserves, Protected Areas and National Parks in Sierra Leone project* in Sierra Leone sought to promote cultural services through increasing forest cover and biodiversity to attract tourists in the region.

Cultural services are the least considered in the climate change adaptation projects. Different studied have sought to explain this scenario. According to Michelle (2012), cultural services are non-material in nature and includes services such as aesthetic aspiration, cultural identity, spiritual fulfillment and cultural identity. However, most of the ecosystem users have shown more interest in the material and tangible benefits from the ecosystems that are largely provisioning and regulatory in nature. The study by Milcu *et al.* (2018) associated the low consideration of cultural services to the subtle and intuitive nature of these services as well as their indirect manifestation. Unlike provisioning, regulatory and supporting services that have tangible and shared value, the cultural value of an ecosystem depends on the individual culture and association with that ecosystem, and therefore varies from one culture to the other (Milcu *et
al., 2018). As such, their economic and market value highly varies and they are in most cases sacrificed in the decision making process. This is evident in the studied projects, whereby only two cases were established as aiming to promote cultural services

4.3.2 Ecosystem services provision in the adaptation projects

The study categorized the climate change adaptation into three; projects with direct ES, projects with indirect ES and projects with no ES as summarized in the Table 4.9 below.

Table 4.9: Ecosystem services provision by the adaptation projects

<table>
<thead>
<tr>
<th>Ecosystem services provision by the adaptation projects</th>
<th>Direct provision</th>
<th>Indirect provision</th>
<th>No ES provision</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of projects</td>
<td>93</td>
<td>62</td>
<td>13</td>
<td>168</td>
</tr>
<tr>
<td>% no. of projects</td>
<td>55</td>
<td>37</td>
<td>8</td>
<td>100</td>
</tr>
</tbody>
</table>

In Burkina Faso, 75% of the projects mentioned direct ecosystem services; Mali had 74% while Cape Verde had 67% of total projects delivering one or more ecosystem services. Mauritania had the highest projects with indirect ES components at 60% while Senegal, Sierra Leone, and Gambia mentioned ES in 50% of their projects. The last category was projects with no ES, with Niger recording the highest number of climate change adaptation projects with no ES at 21% of the total projects studied. The following sections discuss the above findings.

4.3.2.1 Climate change adaptation projects with direct ecosystem service provision

93 of the studied projects accounting for 55% of the total climate change adaptation projects studied were said to have direct ecosystem services when they sought to contribute directly towards any of the four forms of ecosystem service. Projects such as Exploitation of surface water as a means to adapt to climate change in the most vulnerable areas in the Centre and
North Provinces in Benin sought to directly provide water and control soil erosion and siltation in the study area, while Expansion and Intensification of Agro-forestry and Reforestation Activities project in Gambia sought to provide biological support and control erosion. The results were in agreement with Pramova et al. (2012) and Muthee et al. (2017) who established that most of the adaptation projects in place directly mentions or aimed at providing different ecosystem services.

### 4.3.2.2 Climate change adaptation projects with indirect ecosystem service provision

62 projects that accounted for 37% of the total climate change adaptation projects studied sought to indirectly enhance ecosystem services. Some of the initiatives that fell under the category of indirect ecosystem services included the projects that focused on capacity building and awareness creation to the community so that there are in a better position to adapt to the effects of climate change. Capacity building exercises included community trainings, development of training and learning facilities and materials to increase knowledge of climate change adaptation. Projects such as Promoting Environmental Education for coastal communities in Guinea and Increase awareness and knowledge on climate change in Senegal sought to indirectly contribute towards ecosystem services through increasing knowledge and awareness to the community on climate change and ecosystem services. In addition, a number of projects sought to indirectly contribute towards enhancing ecosystem services through early warning systems. Some of the activities put in place included climate monitoring, establishment of early warning systems, installation of meteorological, weather and forecast systems and disaster management systems. Projects such as Mitigating vulnerability to climate change through the strengthening of a prevention and food crisis management system in Oursi and Boulsa in Burkina Faso and
Rehabilitation of early warning system on climate related natural hazards in Gambia. The need for both direct and indirect elements of ecosystem services is noted in various studies such as Braat and Groot (2012) that establishes that an informed community is better positioned to adapt to climate change and promote provision of ecosystem services.

4.3.2.3 Climate change adaptation projects with no ecosystem service provision

These accounted for 8% of the total projects studied. Projects without ecosystem have more negative and less positive impacts on the ecosystems. Some of the projects studies that had no ecosystem services components included Promotion of income-generating activities and developing mutual benefits societies in Niger, Monitoring and control of malaria in the Moyamba districts through supply of mosquito nets in Sierra Leone, and The implementation of a safeguard plan for the town of Nouakchott and its infrastructures in Mauritania. Notably, a significant number of researches have established a link between infrastructural development and ecosystems destruction, posing a major threat to sustainable livelihood and development. It is also noteworthy that majority of these projects without ecosystems services are development-oriented as opposed to ecosystems management oriented. Numerous studies such as Beder (2002) and Raudsepp-Hearne et al. (2010) all point out on the competitive nature of development and environment, noting that it is important to deliberately incorporate environment in development programs and projects to enhance sustainable development.

4.3.3 Projects with single and multiple ES elements

Projects with single ecosystem service element were designed to achieve one service such as clean water, carbon sink, flood control, or ecotourism services in their lifetime. The ecosystem
services provided were largely determined by the project’s thematic areas. Project falling within agricultural thematic area largely provided food as a service while those within water sector were more biased in providing water or regulating water quality. Some examples of projects with single ecosystem service output included the project titled *Fodder crops species introduction in pastoral areas* that sought to increase the fodder provision in the Niger, and *The projects on increasing fish production through aquaculture and conservation of post harvest* in Gambia which sought to increase food production (fish) in Gambia through sustainable aquaculture practices. On the other hand, the project titled *The Rural Zones Sanitation and Water-Supply Improvement Project* in Guinea Bissau aimed at providing water (provisional services) as well as controlling diseases especially cholera that results from poor accessibility to water (regulating services). In addition, the project titled *Development of fodder crops* in Mauritania aimed at increasing provision of fodder (provisional services) to the livestock by planting diverse fodder species, as well as establishing carbon sink and carbon fixation (regulating services). The *Protection of riversides and restoration of silted up ponds* project in Niger sought to provide multiple ecosystem services, notably provision of water for both livestock and farming needs (provisional services) as well as controlling siltation of water ponds (regulating services).

Several reasons can be attributed to single-sectored projects, chiefly being lack of adequate resources to incorporate all the stakeholders and sectors involved in a given ecosystem as well as limited time frame for implementation. Study by Pramova *et al.* (2012) argues that integrating different sectors and stakeholders within adaptation projects is likely to yield better and more sustainable results as opposed to single-sectored projects. It also contributes towards multiple benefits from a single ecosystem. In addition, ecosystems are characterized by interplay among
their various components such as water, forests and agricultural ecosystem; hence the need to develop an integrated approach that meets diverse need from these sectors and thematic areas according to Muthee et al. (2017).

4.4 Areas of redesigning and improvement of climate change adaptation projects

The study revealed that there are various areas of possible redesigning and improvement with an aim to support adaptation at the community level.

One of the areas of improvement is through strengthening the ability of the natural resources to help in the adaptation process and enhance societal livelihoods. The study revealed that strengthening the natural resources through activities such as conserving soils, forests, and water resources can go a long in enhancing community adaptation. Projects such as Restoration and management of Oursi pond in Burkina Faso and Exploitation of surface water as a means to adapt to climate change in the most vulnerable areas in the Centre and North Provinces in Benin revealed that adding activities related to strengthening natural resources improved the ability of ecosystem to function and at the same time aided the community in the climate change adaptation process. Some of the additional and redesigning activities recommended include conservation of the riparian zones, reforestation in the catchment areas and sustainable farming by the small scale farmers in a move to conserve the water resources. This finding was in line with the research by Laurans et al. (2013) that pointed out the need for ecosystems conservation and management as a way of promoting their adaptation capabilities.
The study also portrayed the fundamental role played by alternative livelihoods that are less dependent on the natural resources as a way of adaptation. The analysis revealed that most communities are entirely dependent on natural resources for their existence. This has over the years led to low adaptation and natural resources depletion. Case in study is the Integrated protection and management of Coastal Zones project in Cape Verde that revealed that overreliance of the coastal zones and marine resources had led to their depletion over time, necessitating a form of alternative livelihoods that are less dependent on these resources and more sustainable in the long run. The study revealed that investments in activities such as ecotourism that are less destructive to the ecosystems are ideal in enhancing community adaptation to the climate changes and promoting ecosystem functionality. The findings corroborates with those by Muthee et al. (2017). In addition, alternative livelihood should also incorporate resource management activities such as reforestation coastal zone management and marine biodiversity conservation. This finding corroborates research by Farley & Constanza (2010) that analyzed how payment for ecosystem services can be used as an alternative in conservation of natural resources and promoting community adaptation. In addition, research such as Tschakert et al. (2009) established how exploring other alternative livelihoods have enhanced community adaptation to climate change effects in the Sahel region.

Investment in sustainable agriculture was also identified as key area of redesigning and improvement of adaptation projects. The analysis established that most agricultural projects were conducted on small scale but their combined impact on ecosystem were immerse. This necessitated practices that are less destructive to the ecosystem at small scale levels. Such includes soil conservation and management, use of farm and organic manure, and conservation...
agriculture that are less harmful to the environment and at the same time increases farm productivity. Other measures identified included intercropping and mixed cropping that not only increases productivity but also enhances conservation. Some of the projects within this sector such as *Diversification and Intensification of Agricultural Production, Processing, and Marketing* in Gambia and *Implementation of irrigated rice cultivation in Moyenne and Haute Guinea* in Guinea all pointed out the need for sustainable agricultural measures and approaches for adaptation. This is in tandem with findings of FAO (2006) and Batary (2015) who established that sustainable agricultural practices are ideal in promoting community adaptation.

Financial investment was also established as a key factor in climate change adaptation projects. The ability to conserve ecosystem and benefit from their services is largely determined by the available resources. Researches such as UNFCCC (2011b) and Wamunyima & Miga (2014) pointed out that financial constraints are a major hindrance to effective adaptation to climate change. The analysis revealed that there is a need for more financial investment in building knowledge and capacity of the small scale farmers to adapt to climate change effects. This can be ensured through opening up microfinance and insurances to the farmers to reduce climate vulnerability.

The analysis also revealed that there is need for capacity development through trainings and demonstrations on ways to promote adaptation. Some of the approaches include sustainable fishing, water utilization, forestry management and marine biodiversity conservation. Projects such as *Increase awareness and knowledge on climate change* in Senegal and *Support and assistance to the rural communities of the regions of Savanes and Plateaux to prevent and fight*
vector borne diseases in Togo demonstrated the role of capacity development as a way of community adaptation. However, only 10% of these projects actually mentioned capacity development portraying a big gap that needs to be bridged so that the communities have the right set of skills and experience in promoting ecosystem services using different projects.
CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the study

The study revealed that there was notable change in the ecosystems of the least developed countries in West Africa between 2000 and 2010, with a decline in forest cover and increase in savanna land, which eventually paved way for desert ecosystems. This change was highly attributed to anthropogenic factors such as logging and clearing forests for commercial usage. This change contributed to the climate change effects as tree covers that acted as carbon sinks were removed from the ecosystems leading to increased accumulation of greenhouse gases in the atmosphere that are responsible for climate change.

Climate change adaptation projects in the least developed West Africa Countries exhibited a predictable trend, with more focus on the agricultural sector, short-term implementation period, low budgetary allocation, and sub-national spatial and geographical coverage.

The extent to which the climate change adaptation projects incorporated ecosystem services revealed that 55%, 36% and 9% of the projects had directly, indirectly or had no incorporation of ecosystem services respectively. The dominant category of ecosystem services was provisioning at 50% while 61% of the projects provided single ecosystem service.

The study established that there are several areas of redesigning and improving climate change adaptation projects to enhance ecosystem services which include increasing the natural resources management, increasing the use of alternative livelihoods that are less dependent on natural resources and increasing the financial incentives towards sustainable usage of natural resources.
5.2 Study conclusions

1. There is a significant change of the ecosystems in the least developed countries of West Africa

2. The climate change adaptation projects are largely within agricultural sector, have short-term implementation duration, low budgetary allocation and at sub-national scale of implementation

3. Most of the climate change adaptation projects studied had ecosystem services elements but only a small percentage of them considered the multiplicity of ecosystem services in a single project. There lacks a holistic approach in the design to ensure that diverse ecosystem and ecosystem services needs are met by a single project.

4. There exist several areas of redesigning the climate change adaptation projects to enhance their ability to provide ecosystem services, including financial incentives and sustainable usage of natural resources.

5.3 Study recommendations

Based on the study conclusions it is recommended as follows:

1. There is need for increased climate change adaptation projects to address ecosystem degradation and help the communities in adapting to the climate change effects.

2. There is need to consider more implementation time, financial consideration, and localization of the climate change adaptation projects to meet their objectives effectively

3. Climate change adaptation projects should take a more holistic approach to achieve multiple services within a single project.
4. The study also recommends exploration of redesigning options in the least developed countries’ climate change adaptation projects in West Africa to enhance ecosystem services provided

5.4 Recommendations for further research

One of the areas for further research is the impacts of Great Green Wall on ecosystem services in West Africa. Research should be conducted to assess if the project is enhancing ecosystem services within the project area and meeting its objectives in the wake of climate change and its effects to the least developed West Africa countries.
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ANNEX 1: NAPA documents studied

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**Total projects reviewed**: 168